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Goto et al.

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(54) **STEAM TURBINE PLANT**

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(73) Assignee: **KABUSHIKI KAISHA TOSHIBA**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 329 days.

This patent is subject to a terminal disclaimer.

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Jul. 27, 2011 (JP) 2011-164613

(51) **Int. Cl.**
F01K 7/22 (2006.01)
F01K 7/40 (2006.01)

(52) **U.S. Cl.**
CPC ***F01K 7/22*** (2013.01); ***F01K 7/223*** (2013.01); ***F01K 7/40*** (2013.01)

(58) **Field of Classification Search**
CPC F01K 7/22; F01K 7/40; F01K 7/223
USPC 60/653, 654, 661–662, 677–680
See application file for complete search history.

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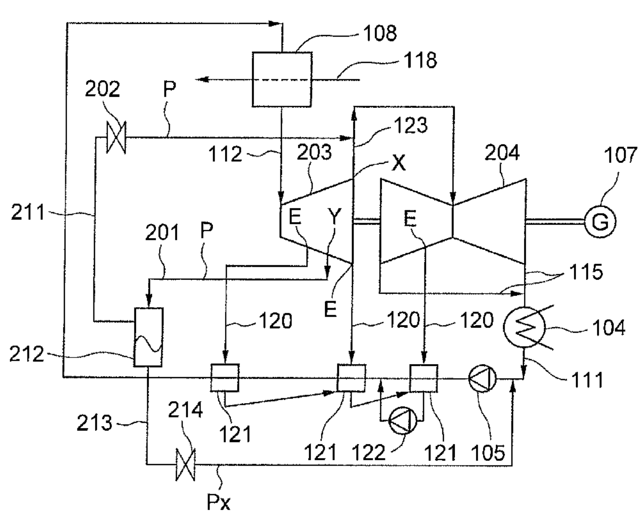
(57) **ABSTRACT**

A steam turbine plant of one embodiment includes a boiler to change water into steam, an upstream turbine including plural stages of rotor vanes and plural stages of stator vanes and to be driven by the steam from the boiler, a downstream turbine including plural stages of rotor vanes and plural stages of stator vanes and to be driven by the steam from the upstream turbine, a condenser to change the steam exhausted from the downstream turbine into water, a collector to collect water from, for example, the steam which exists upstream of an inlet of the final-stage rotor vane in the upstream turbine, and a collected matter path to cause collected matter in the collector to flow into, for example, the steam between an outlet of the final-stage rotor vane of the upstream turbine and an inlet of the final-stage rotor vane of the downstream turbine.

11 Claims, 10 Drawing Sheets



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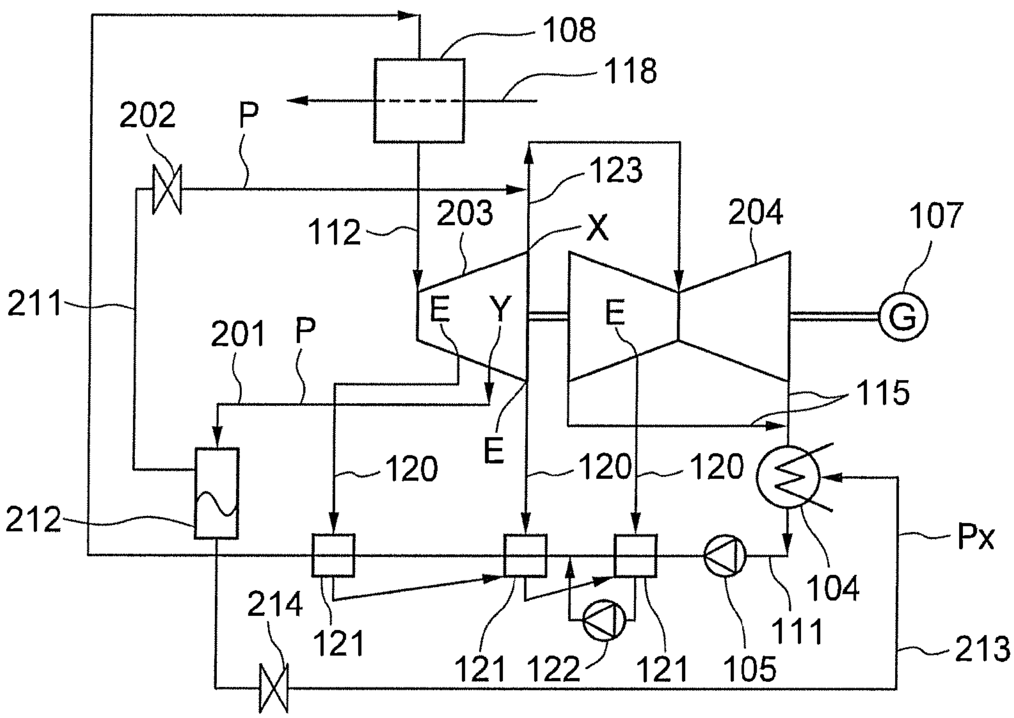

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FIG.1

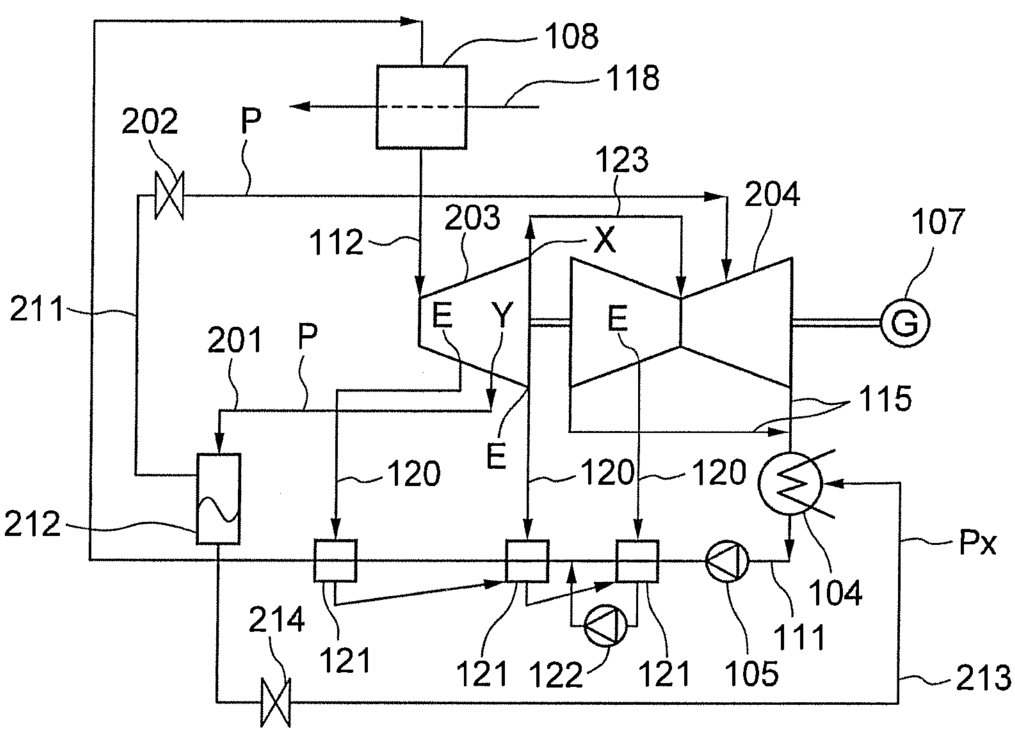

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FIG.2

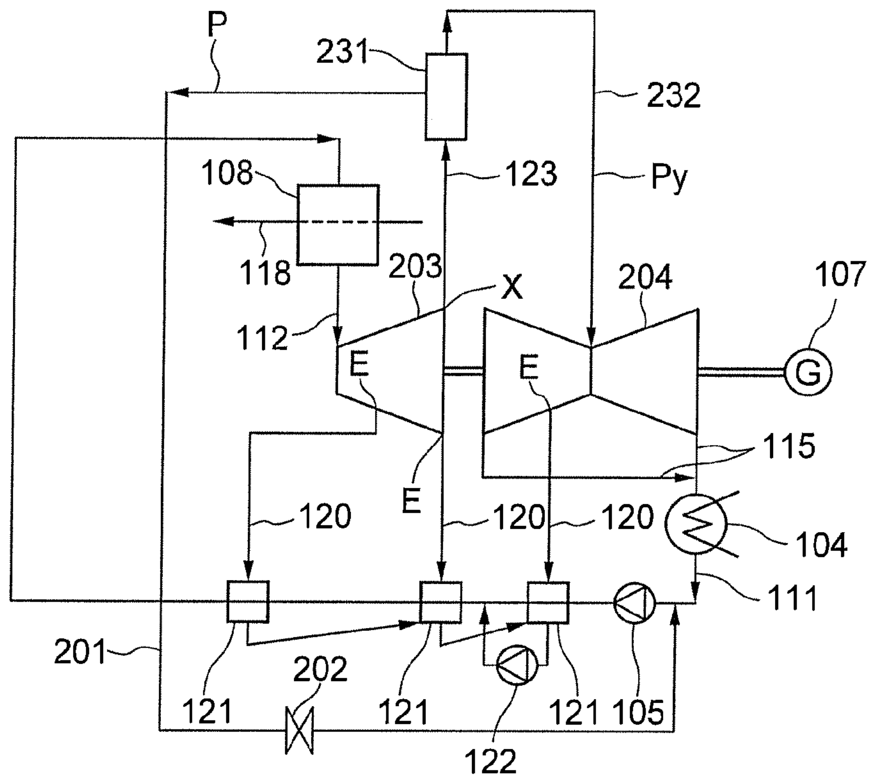
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FIG.3

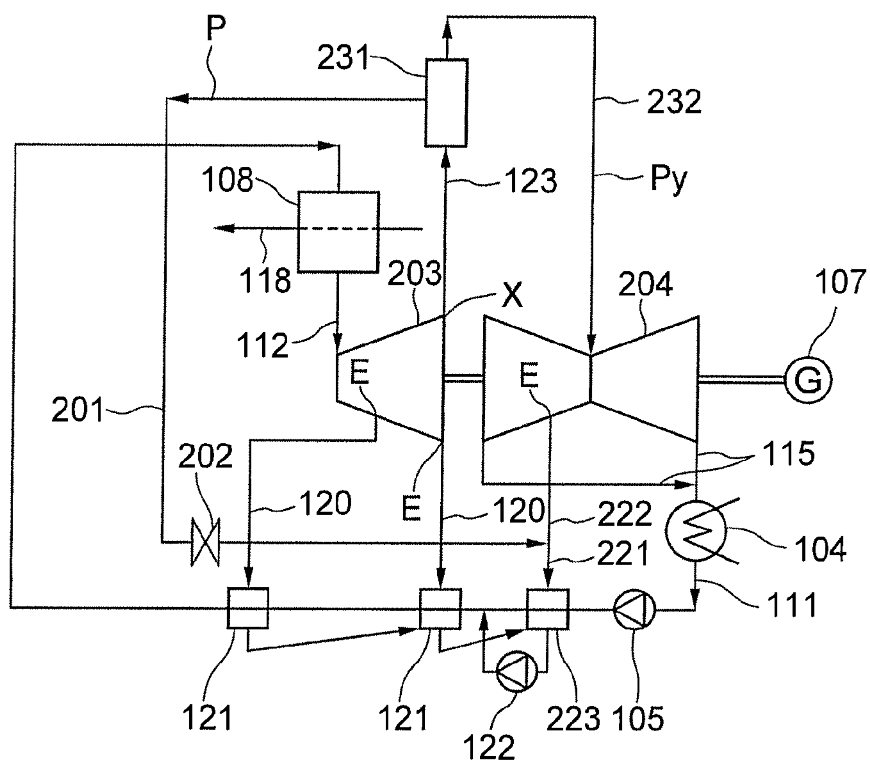
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FIG.4

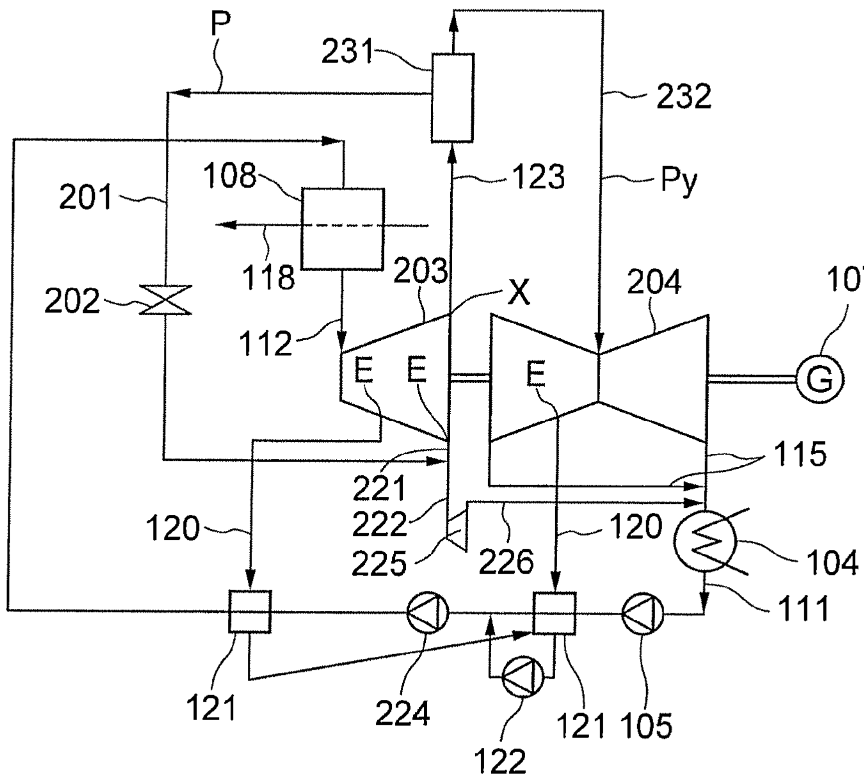
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FIG.5

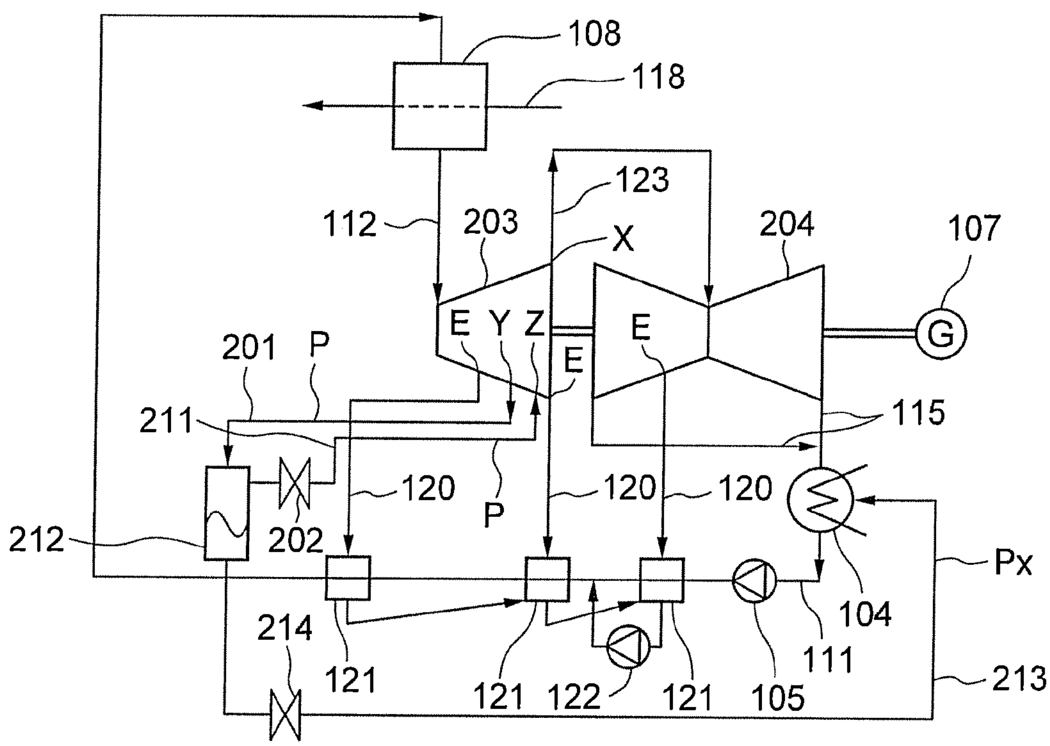
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FIG.6

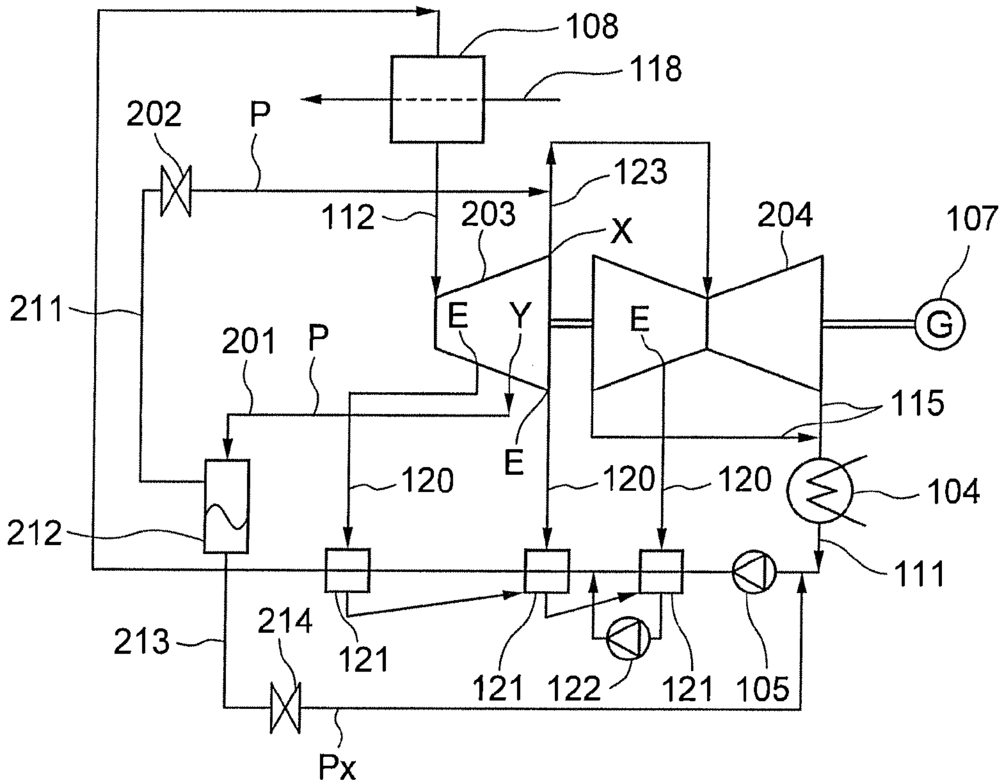
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FIG.7

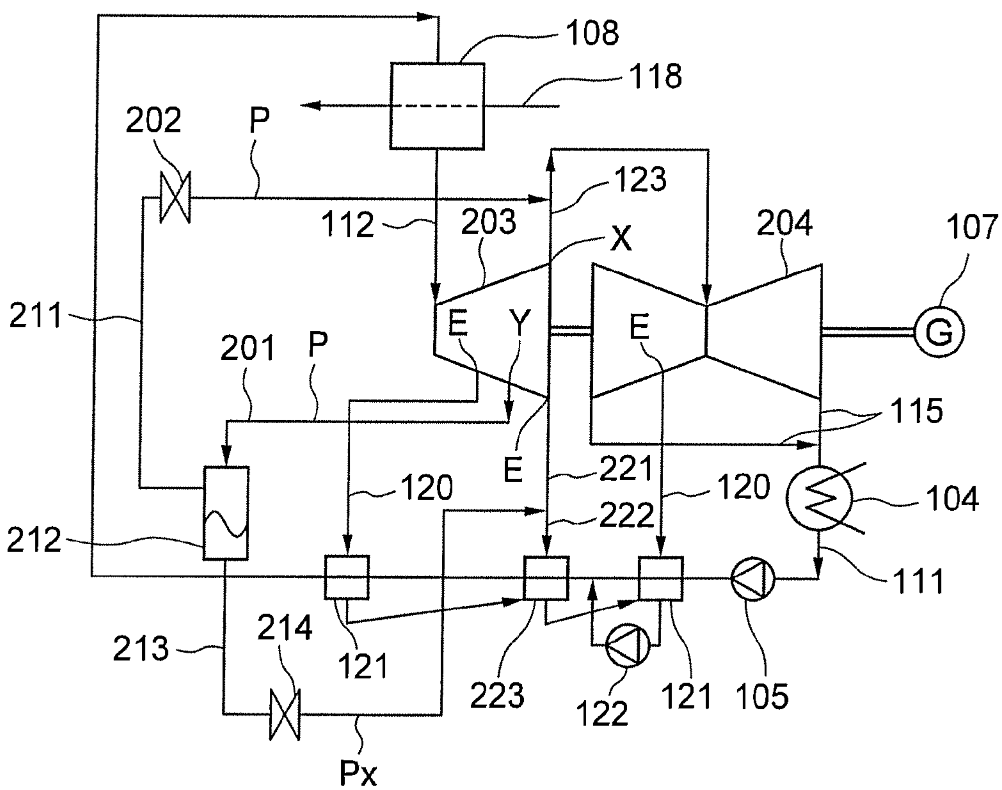
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FIG.8

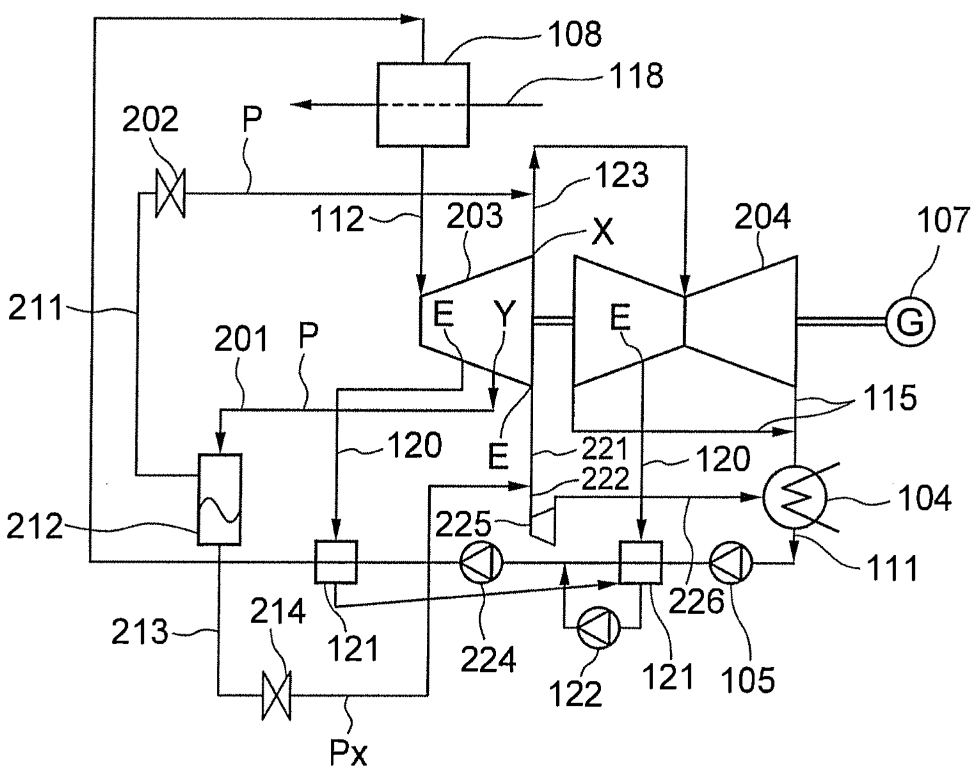
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FIG.9

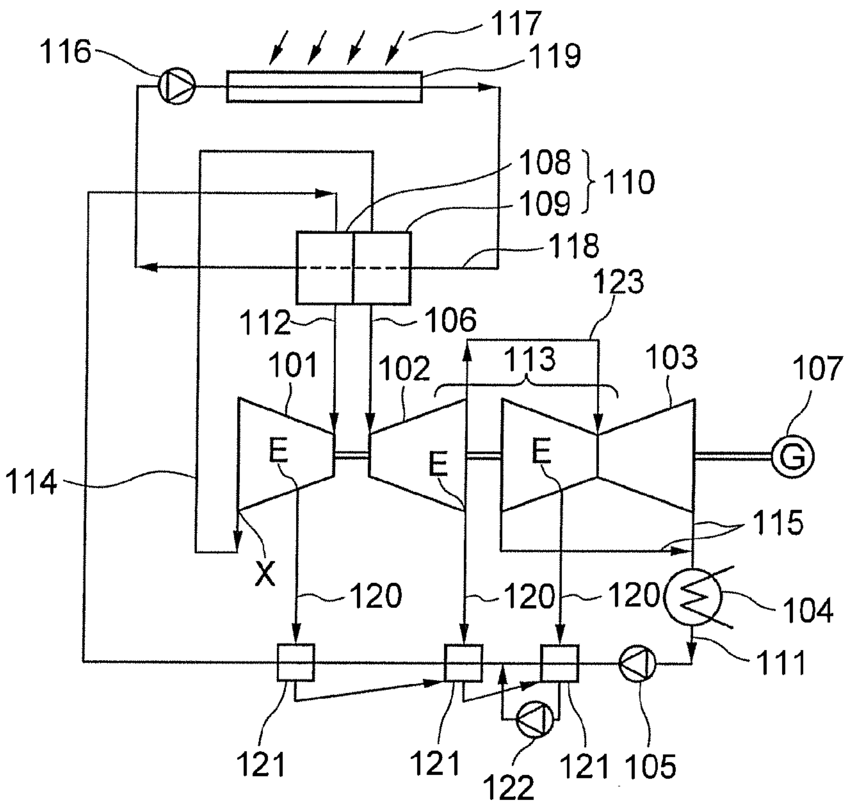

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FIG.10

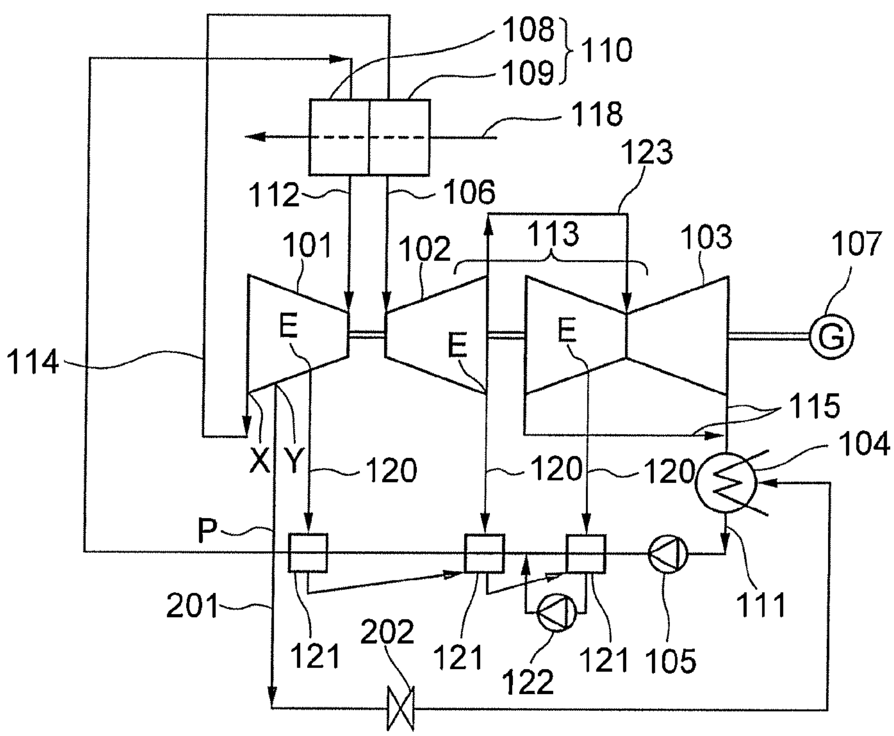

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FIG.11

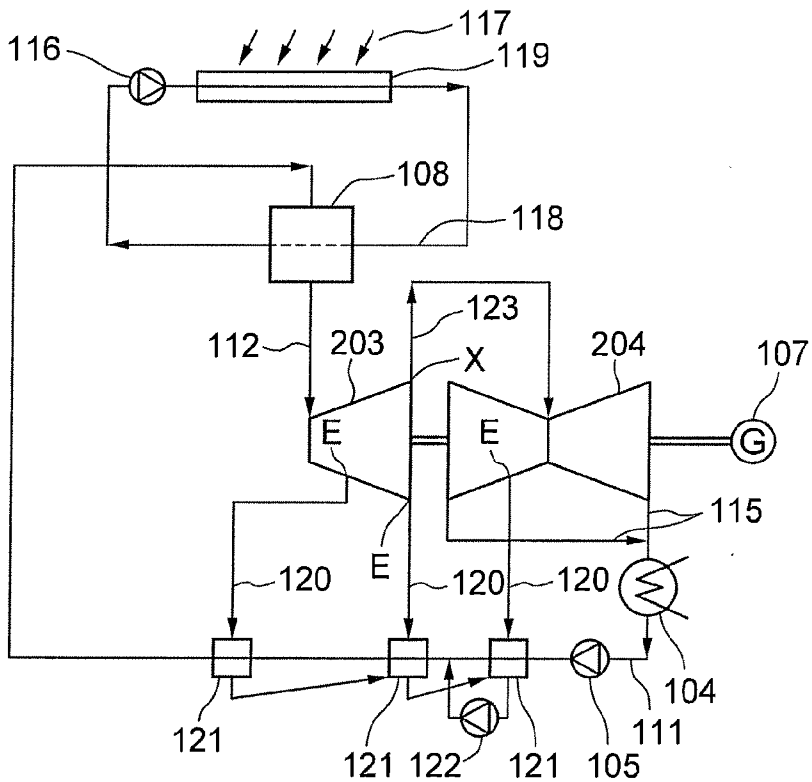
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FIG.12

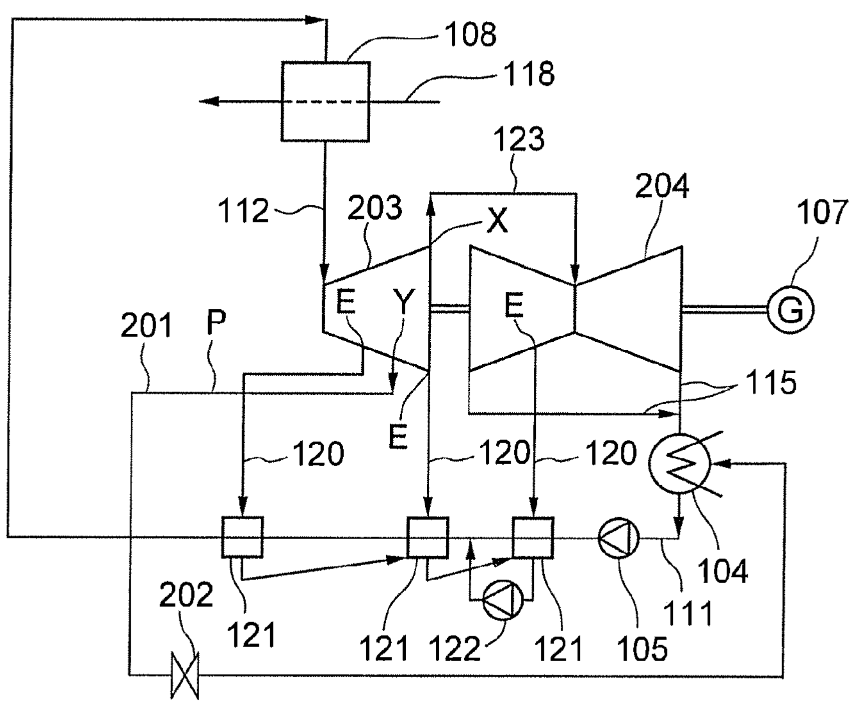
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FIG.13

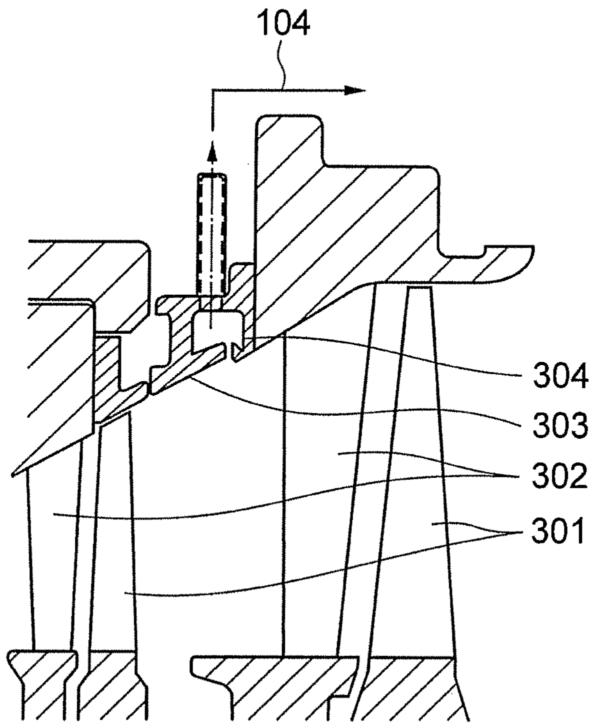


FIG.14

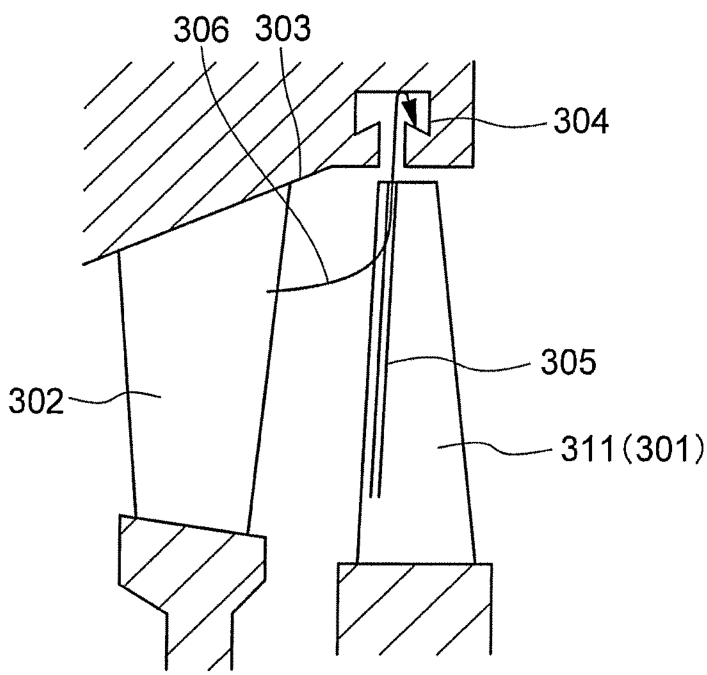


FIG.15

FIG.16

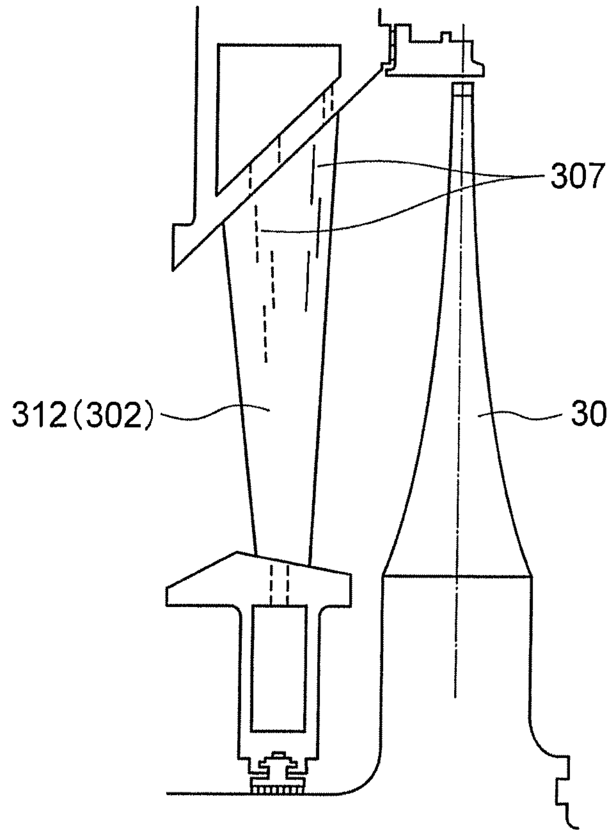


FIG.17

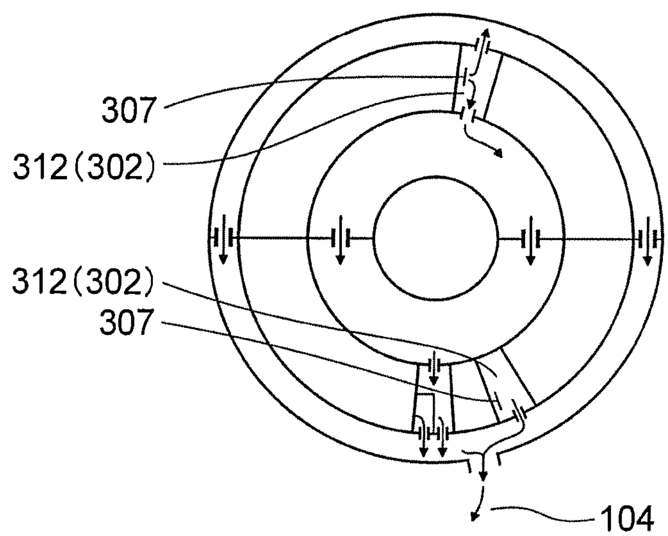
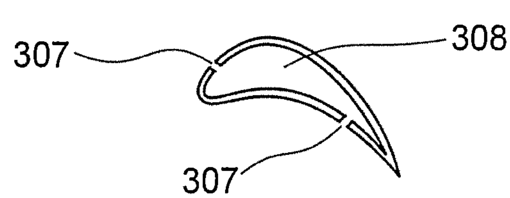


FIG.18



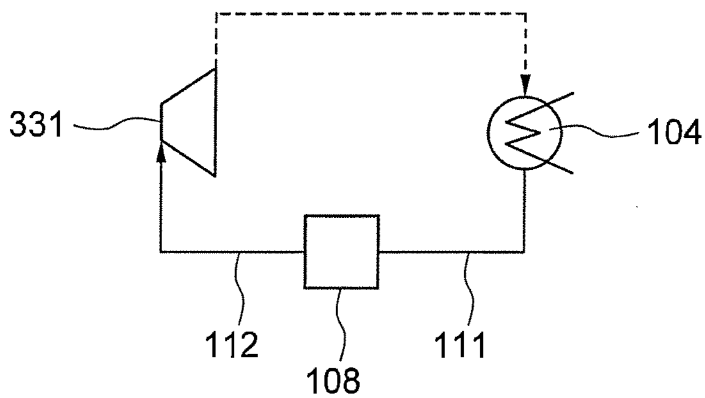


FIG.19A

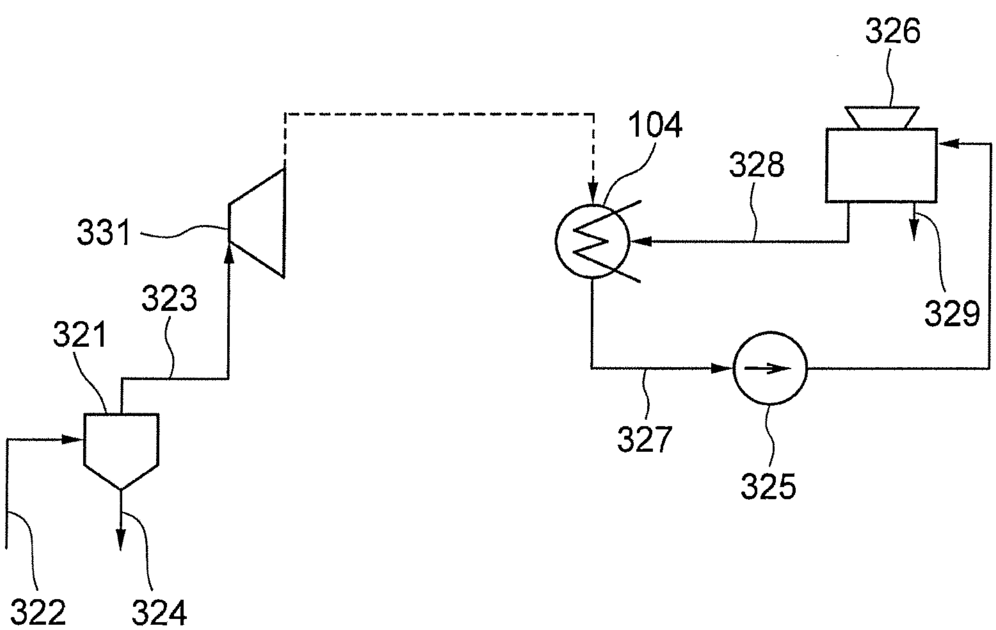


FIG.19B

STEAM TURBINE PLANT

CROSS REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from the prior Japanese Patent Applications No. 2010-234821, filed on Oct. 19, 2010 and No. 2011-164613, filed on Jul. 27, 2011, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a steam turbine plant, for example, including a collector configured to collect water from steam in an upstream turbine or stream exhausted from the upstream turbine.

2. Background Art

FIG. **10** is a schematic diagram illustrating a first example of a conventional steam turbine plant using solar heat. A steam turbine cycle in the plant of FIG. **10** will be described.

A heat medium **118** is transferred by a heat medium pump **116** to a solar energy collector **119** collecting solar heat. The heat medium **118** is, for example, oil. The heat medium **118** is heated by radiant heat of solar rays **117** in the solar energy collector **119**. Subsequently, the heat medium **118** is transferred to a heater **110** which is a heat exchanger to heat water or steam corresponding to a heating object. The heat medium **118** decreases in temperature in the heater **110**, and returns to the upstream of the heat medium pump **116**. In this manner, the heat medium **118** circulates.

The heat medium **118** stored in a heat storage tank is circulated while bypassing the solar energy collector **119** at night time when solar rays **117** cannot be received or daytime when the solar rays **117** are weak, but the equipment and the flow for this configuration are not shown herein.

The steam turbine cycle of FIG. **10** is configured as a single-stage reheat cycle which is a reheat turbine **113** including a high pressure turbine **101**, an intermediate pressure turbine **102**, and a low pressure turbine **103**.

The heater **110** includes a boiler **108** which changes feed-water **111** into steam **112** and a reheater **109** which heats steam dedicated for the reheat turbine **113**. The feed-water **111** is transferred by a condensed water pump **105** to the boiler **108** which is a part of the heater **110** and is heated at the boiler **108**, so that it changes into the high pressure turbine inlet steam **112**.

The high pressure turbine inlet steam **112** flows into the high pressure turbine **101** and expands inside the high pressure turbine **101**, so that the pressure and the temperature all decrease. The high pressure turbine **101** is driven by the high pressure turbine inlet steam **112**. In the steam turbine cycle using solar heat, the temperature of the high pressure turbine inlet steam **112** is low in many cases compared to the steam turbine cycle using exhaust heat of a combustion gas of a fuel. For this reason, the high pressure turbine exhaust **114** is not dry steam only composed of a gas, but humid steam composed of a mixture of a gas and a liquid. That is, the dryness of the humid steam is less than 1 in many cases.

In FIG. **10**, the outlet (exhaust port) located at the most downstream of the high pressure turbine **101** is denoted by the reference character X. The high pressure turbine exhaust **114** flows into the reheater **109** which is a part of the heater **110** to be heated therein, and flows into the intermediate pressure turbine **102**.

The intermediate pressure turbine inlet steam **106** expands inside the intermediate pressure turbine **102**, decreases in both the pressure and the temperature, and flows into the low pressure turbine **103**. The low pressure turbine **103** of FIG. **10** is a double flow type in which the intermediate pressure turbine exhaust **123** flows from the center of the low pressure turbine **103** to left and right and flows out of two outlets. The steam flowing into the low pressure turbine **103** expands inside the low pressure turbine **103**, decreases in both the pressure and the temperature, and flows out as humid steam. Due to this steam, the intermediate pressure turbine **102** and the low pressure turbine **103** are driven as in the high pressure turbine **101**.

The steam flowing out of the low pressure turbine **103**, that is, the low pressure turbine exhaust **115** flows into a condenser **104**. The condenser **104** cools the low pressure turbine exhaust **115** using cooling water, and changes the cooled exhaust into feed-water **111**. The feed-water **111** is returned to the upstream of the condensed water pump **105**. In this manner, the feed-water **111** circulates while changing into the steam **112**. Furthermore, seawater or stream water may be used as the cooling water, and the cooling water increasing in the temperature in the condenser **104** may be circulated by being cooled in a cooling tower using atmosphere.

The rotary shafts of the high pressure turbine **101**, the intermediate pressure turbine **102**, and the low pressure turbine **103** are connected to a generator **107**. The rotary shaft is rotated with the rotation of the high pressure turbine **101**, the intermediate pressure turbine **102**, and the low pressure turbine **103** due to the expanding steam. The generator **107** generates power in accordance with the rotation of the rotary shaft.

In FIG. **10**, the extraction ports provided at the halfway stages of the high pressure turbine **101**, the intermediate pressure turbine **102**, and the low pressure turbine **103** are denoted by the reference character E, and extraction steam **120** is extracted from one or more of the extraction ports E. In FIG. **10**, a recycling cycle (a reheat recycling cycle) is configured such that the feed-water **111** is heated by the extraction steam **120** serving as a heat source in the feed-water heater **121** between the condenser **104** and the boiler **108**. The cycle of FIG. **10** may not be the recycling cycle, but the efficiency of the cycle improves in the recycling cycle.

Furthermore, the extraction steam **120** is cooled in the feed-water heater **121** to change into water, and merges with the feed-water **111** by a drain water pump **122**.

FIG. **11** is a schematic diagram illustrating a second example of the conventional steam turbine plant using solar heat. In FIG. **11**, the flow of the heat medium **118** is not shown, and this will not be illustrated even in the respective drawings other than FIG. **12** to be described later.

In many cases, the inlet steam of the reheat cycle using solar heat is close to a humid region with, for example, a pressure of 110 ata and a temperature of 380° C. in the enthalpy-entropy diagrammatic view, and the high pressure turbine exhaust **114** becomes humid steam. The humid steam inside the high pressure turbine **101** causes humidity loss, and deteriorates the internal efficiency of the turbine. Further, since water droplets collide with the surface of the turbine vane of the high pressure turbine **101**, erosion is caused.

Therefore, the high pressure turbine **101** of FIG. **11** includes a collector which collects water from the steam inside the high pressure turbine **101**. Then, the steam turbine plant of FIG. **11** includes a collected matter path P which makes collected matter **201** collected by the collector flow into the condenser **104**. In FIG. **11**, the collection place where water is collected from the high pressure turbine **101** is denoted by the reference character Y. The collected matter **201** flows from the collection place Y into the condenser **104** through the collected matter path P. In some cases, the collected matter **201** may contain humid steam or dry steam collected with water as well as the collected water.

FIG. **12** is a schematic diagram illustrating a third example of the conventional steam turbine plant using solar heat. The steam turbine cycle in the plant of FIG. **12** will be described. In the configuration shown in FIG. **12**, the difference from the configuration shown in FIG. **10** will be mainly described.

The steam turbine cycle of FIG. **10** is the reheat cycle including the high pressure turbine **101** and the reheat turbine **113**. On the contrary, the steam turbine cycle of FIG. **12** is a non-reheat cycle including an upstream turbine **203** and a downstream turbine **204**.

In FIG. **12**, the feed-water **111** is transferred by the condensed water pump **105** to the boiler **108**. Then, the feed-water **111** is heated by the boiler **108**, so that it changes into upstream turbine inlet steam **112**.

The upstream turbine inlet steam **112** flows into the upstream turbine **203** and expands inside the upstream turbine **203**, so that the pressure and the temperature all decrease. The upstream turbine **203** is driven by the upstream turbine inlet steam **112**. In the steam turbine cycle using solar heat, the temperature of the upstream turbine inlet steam **112** is low in many cases compared to the steam turbine cycle using exhaust heat of a combustion gas of a fuel. For this reason, the upstream turbine exhaust **123** is not dry steam only composed of a gas, but humid steam composed of a mixture of a gas and a liquid. That is, the dryness of the humid steam is less than 1 in many cases.

In FIG. **12**, the outlet (exhaust port) located at the most downstream of the upstream turbine **203** is denoted by the reference character X. The upstream turbine exhaust **123** flows into the downstream turbine **204**. The upstream turbine exhaust **123** expands inside the downstream turbine **204**, and decreases in both the pressure and the temperature. The downstream turbine **204** is driven by the upstream turbine exhaust **123**.

The steam flowing out of the downstream turbine **204**, that is, the downstream turbine exhaust **115** flows into the condenser **104**. The condenser **104** cools the downstream turbine exhaust **115** using cooling water, and changes the cooled exhaust into the feed-water **111**. The feed-water **111** is returned to the upstream of the condensed water pump **105**. In this manner, the feed-water **111** circulates while changing into the steam **112**.

The rotary shafts of the upstream turbine **203** and the downstream turbine **204** are connected to the generator **107**. The rotary shaft is rotated by the rotation of the upstream turbine **203** and the downstream turbine **204** caused by the expanding steam. The generator **107** generates power in accordance with the rotation of the rotary shaft.

FIG. **13** is a schematic diagram illustrating a fourth example of the conventional steam turbine plant using solar heat. In FIG. **13**, the flow of the heat medium **118** is not shown, and this will not be illustrated even in the respective drawings to be described later.

The upstream turbine **203** of FIG. **13** includes a collector that collects water from the steam inside the upstream turbine **203** due to the same reason in the high pressure turbine **101** of FIG. **11**. Then, the steam turbine plant of FIG. **13** includes a collected matter path P which makes collected matter **201** collected by the collector flow into the condenser **104**. In FIG. **13**, the collection place where water is collected from the upstream turbine **203** is denoted by the reference character Y. The collected matter **201** flows from the collection place Y into the condenser **104** through the collected matter path P. In some cases, the collected matter **201** may contain humid steam or dry steam collected with water as well as the collected water.

Hereinafter, first to third configuration examples of the collector of the steam turbine plant of FIG. **13** will be described.

FIG. **14** is a schematic diagram illustrating a first example of the collector.

As shown in FIG. **14**, the upstream turbine **203** includes plural stages of rotor vanes **301** and plural stages of stator vanes **302**. Then, in FIG. **14**, a drain catcher **304** is provided at an inner wall surface **303** on the outer peripheral side of the steam passage. The drain catcher **304** is a first configuration example of the collector.

The drain catcher **304** is connected to the condenser **104** through the pipe (the collected matter path P). Since the internal pressure of the condenser **104** is lower than that of the upstream turbine **203**, moisture present in the inner wall surface **303** is suctioned outward as the collected matter **201**, and flows into the condenser **104**. Accordingly, the amount of the moisture contained in the steam inside the upstream turbine **203** decreases.

FIG. **15** is a schematic diagram illustrating a second example of the collector.

There is shown a groove attached rotor vane **311** configured to more actively remove moisture than the first configuration example. In FIG. **15**, a groove **305** is provided at the surface of a rotor vane **301** (**311**) of a turbine stage to which humid steam flows, so that water droplets **306** contained in the humid steam are captured. The captured water droplets **306** move toward the outer periphery of the rotor vane **301** along the groove **305** due to the centrifugal force exerted on the surface of the rotating rotor vane **301**. Then, the water droplets **306** fly toward the drain catcher **304** provided on the inner wall surface **303**.

The drain catcher **304** is connected to the condenser **104** through the pipe (the collected matter path P). Since the internal pressure of the condenser **104** is lower than that of the upstream turbine **203**, the moisture present inside the drain catcher **304** is suctioned outward as the collected matter **201**, and flows into the condenser **104**. Accordingly, the amount of the moisture contained in the steam inside the upstream turbine **203** decreases. The drain catcher **304** and the groove attached rotor vane **311** are a second configuration example of the collector.

The collector shown in FIG. **14** or **15** may be provided in the downstream turbine **204**. However, when the groove attached rotor vane **311** is applied to the final-stage rotor vane **301** of the downstream turbine **204**, no effect is obtained since there is no rotor vane **301** at the downstream of the final-stage rotor vane. For this reason, the groove attached rotor vane **311** is applied to the rotor vane **301** which is located upstream of the final-stage rotor vane **301** of the downstream turbine **204**.

FIGS. **16** to **18** are schematic diagrams illustrating a third example of the collector.

There is shown a slit attached stator vane **312** configured to more actively remove moisture than the first configuration example. FIG. **16** is a diagram when the slit attached stator vane **312** is seen from the cross-section including the rotary shaft of the turbine, and FIG. **17** is a diagram when the slit attached stator vane **312** is seen from the cross-section perpendicular to the rotary shaft of the turbine. Further, FIG. **18** is a diagram illustrating the cross-section perpendicular to the radial direction with respect to one slit attached stator vane **312**.

In FIGS. **16** to **18**, a slit **307** is provided on the surface of the stator vane **302** (**312**) at the turbine stage to which humid steam flows. In addition, a hollow space **308** is provided inside the stator vane **312**, and the stator vane **312** is configured as a hollow vane. The surface of the stator vane **312** and the hollow space **308** are connected to each other through the slit **307**. The slit attached stator vane **312** is a third configuration example of the collector.

The hollow space **308** is connected to the condenser **104** through the slit **307** and the pipe (the collected matter path P). Since the internal pressure of the condenser **104** is lower than that of the vicinity of the slit **307**, the water droplets **306** or the water membrane flowing to the surface of the slit attached stator vane **312** are suctioned outward as the collected matter **201**, and flows into the condenser **104**. Accordingly, the amount of the moisture contained in the upstream turbine **203** decreases.

Further, the water droplets **306** or the water membrane flowing to the surface of the stator vane **302** are separated from the surface of the stator vane **302** in the form of water droplets and scatter to the downstream, so that the water droplets collide with the downstream rotor vane **301**. However, according to the slit attached stator vane **312**, the amount of the colliding water droplets **306** particularly decreases in this manner.

The collector shown in FIGS. **16** to **18** may be provided in the downstream turbine **204**.

Furthermore, since the downstream turbine exhaust **115** decreases in the pressure until it changes into humid steam regardless of the property and the state of the inlet steam, in the steam turbine cycle using solar heat, the upstream turbine exhaust **123** and the downstream turbine exhaust **115** are humid steam.

Further, the collector shown in FIGS. **14** to **18** may be provided in the high pressure turbine **101**, the intermediate pressure turbine **102**, or the low pressure turbine **103** of the steam turbine plant of FIG. **11**.

Furthermore, JP-A 2006-242083 (KOKAI) discloses an example of a steam turbine plant that is equipped with a moisture separator.

Further, JP-A H11-22410 (KOKAI), JP-A 2004-124751 (KOKAI), and JP-A H11-159302 (KOKAI) disclose examples of a steam turbine plant that is equipped with a collector for collecting moisture.

SUMMARY OF THE INVENTION

Here, the problem of the steam turbine plant of FIGS. **11** and **13** will be described by referring to FIG. **13**.

In FIG. **13**, when moisture is removed from the upstream turbine **203**, the flow rate of the steam from all downstream turbines decreases as much as the amount of the extracted moisture. For this reason, the output of the power generation of the plant decreases, and the performance of the steam turbine cycle deteriorates. The performance of the steam turbine cycle refers to, for example, a value of the output of the power generation per unit heat input. The greater value, the better the performance of the steam turbine cycle is. Furthermore, the entire downstream turbine includes the turbine stage at the downstream of the extraction position of the moisture in the upstream turbine **203**, and the downstream turbine **204**.

Further, in the case of applying the slit attached stator vane **312**, the humid steam is also suctioned out when the moisture on the surface of the vane is suctioned out of the slit **307**. The humid steam contains water and gaseous steam. For this reason, the gaseous steam is suctioned outside during the suction. This reduces the amount of the fluid for driving the turbine.

In FIG. **13**, a valve **202** is provided on a suction line (a collected matter path P) from the collector to the condenser **104**. Then, a difference in the suction pressure (here, a difference in the pressure between the vicinity of the slit **307** and the condenser **104**) is adjusted on the basis of the opening degree of the valve **202** so that the suction amount of the accompanying steam decreases when the moisture on the surface of the vane is suctioned.

However, since it is extremely difficult to suction only the moisture on the surface of the vane without suctioning the accompanying steam, the flow rate of the steam of the entire downstream turbine decreases as much as the amount of the accompanying steam. For this reason, the output of the power generation of the plant decreases and the performance of the steam turbine cycle deteriorates. Although the enthalpy of the accompanying steam is sufficiently high and the enthalpy of the accompanying steam can be extracted by at the turbine unlike the water, in FIG. **13**, the enthalpy is exhausted to the condenser **104** rather than extracted. Accordingly, the output of the power generation decreases even in the upstream turbine **203**.

Further, the temperature of the moisture exhausted from the upstream turbine **203** is sufficiently high inside the upstream turbine **203**, but if the moisture is not removed, the enthalpy should be extracted at the downstream turbine **204**. However, if the moisture exhausted from the upstream turbine **203** is removed, the sufficient sensible heat of the moisture ends up unused. That is, it is transferred to the condenser **104** and discarded, so that the performance of the steam turbine cycle deteriorates.

Therefore, an object of the invention is to provide a steam turbine plant capable of reducing deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle which are concomitant with the removal of moisture in a case where the moisture is removed from the steam inside the upstream turbine **203** or the exhaust of the upstream turbine **203**.

An aspect of the present invention is, for example, a steam turbine plant including a boiler configured to change water into steam, an upstream turbine including plural stages of rotor vanes and plural stages of stator vanes, and configured to be driven by the steam from the boiler, a downstream turbine including plural stages of rotor vanes and plural stages of stator vanes, and configured to be driven by the steam from the upstream turbine, a condenser configured to change the steam exhausted from the downstream turbine into water, a collector configured to collect water from the steam which exists upstream of an inlet of the final-stage rotor vane in the upstream turbine, or the steam exhausted from the upstream turbine, and a collected matter path configured to cause collected matter in the collector to flow into the steam between an outlet of the final-stage rotor vane of the upstream turbine and an inlet of the final-stage rotor vane of the downstream turbine, the steam between a collection place of the collected matter and the inlet of the final-stage rotor vane in the upstream turbine, the water between the condenser and the boiler, the steam extracted from an extraction port of the upstream turbine or the downstream turbine, a feed-water heater configured to receive the extracted steam from the extraction port, or a feed-water pump driving steam turbine configured to receive the extracted steam from the extraction port.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating a configuration of a steam turbine plant of a first embodiment;

FIG. **2** is a schematic diagram illustrating a configuration of a steam turbine plant of a second embodiment;

FIG. **3** is a schematic diagram illustrating a configuration of a steam turbine plant of a third embodiment;

FIG. **4** is a schematic diagram illustrating a configuration of a steam turbine plant of a fourth embodiment;

FIG. **5** is a schematic diagram illustrating a configuration of a steam turbine plant of a fifth embodiment;

FIG. **6** is a schematic diagram illustrating a configuration of a steam turbine plant of a sixth embodiment;

FIG. **7** is a schematic diagram illustrating a configuration of a steam turbine plant of a seventh embodiment;

FIG. **8** is a schematic diagram illustrating a configuration of a steam turbine plant of an eighth embodiment;

FIG. **9** is a schematic diagram illustrating a configuration of a steam turbine plant of a ninth embodiment;

FIG. **10** is a schematic diagram illustrating a first example of a conventional steam turbine plant;

FIG. **11** is a schematic diagram illustrating a second example of a conventional steam turbine plant;

FIG. **12** is a schematic diagram illustrating a third example of a conventional steam turbine plant;

FIG. **13** is a schematic diagram illustrating a fourth example of a conventional steam turbine plant;

FIG. **14** is a schematic diagram illustrating a first example of a collector;

FIG. **15** is a schematic diagram illustrating a second example of a collector;

FIG. **16** is a schematic diagram illustrating a third example of a collector;

FIG. **17** is another schematic diagram illustrating the third example of the collector;

FIG. **18** is another schematic diagram illustrating the third example of the collector; and

FIGS. **19**A and **19**B are schematic diagrams illustrating configurations of steam turbine plants for solar power generation and geothermal power generation, respectively.

DESCRIPTION OF THE EMBODIMENTS

Embodiments of the invention will now be explained with reference to the accompanying drawings.

(First Embodiment)

FIG. **1** is a schematic diagram illustrating a configuration of a steam turbine plant of a first embodiment. Regarding the configuration shown in FIG. **1**, differences from the configurations shown in FIGS. **12** and **13** will be mainly described.

The steam turbine plant of the embodiment is configured as a non-reheat cycle as in the steam turbine plant shown in FIG. **12** or **13**, where an upstream turbine **203** and a downstream turbine **204** are directly connected to each other in series without using a reheater.

Further, the upstream turbine **203** of the embodiment includes plural stages of rotor vanes **301** and plural stages of stator vanes **302** as in the upstream turbine **203** shown in FIG. **12** or **13** (refer to FIG. **14**). In the same manner, the downstream turbine **204** of the embodiment includes plural stages of rotor vanes and plural stages of stator vanes. Further, the upstream turbine **203** of the embodiment includes one turbine or a plurality of turbines connected to each other in series. In the same manner, the downstream turbine **204** of the embodiment includes one turbine or a plurality of turbines connected to each other in series.

Further, in the upstream turbine **203** of the embodiment, the steam circulating therein changes into humid steam as in the upstream turbine **203** shown in FIG. **12** or **13**. Therefore, the upstream turbine **203** of the embodiment is provided with a collector that collects moisture from the steam inside the upstream turbine **203**. Examples of the collector include a drain catcher **304** shown in FIG. **14**, a drain catcher **304** and a groove attached rotor vane **311** shown in FIG. **15**, a slit attached stator vane **312** shown in FIGS. **16** to **18**, and the like.

Furthermore, in the embodiment, the collector is disposed at a position where moisture is collected from the steam which exists upstream of the inlet of the final-stage rotor vane **301** inside the upstream turbine **203**. Further, in the embodiment, the collector is disposed at a position where moisture is collected from the steam of a humid region inside the upstream turbine **203**.

Collected matter **201** obtained by the collector is moisture when the collector is the drain catcher **304** or the drain catcher **304** and the groove attached rotor vane **311**, and is moisture and accompanying steam when the collector is the slit attached stator vane **312**.

The steam turbine plant of the embodiment includes a collected matter path P which makes the collected matter **201** flow into not a condenser **104**, but the steam between the outlet of the final-stage rotor vane **301** of the upstream turbine **203** and the inlet of the final-stage rotor vane of the downstream turbine **204**. Specifically, the collected matter path P of the embodiment makes the collected matter **201** flow into a position between the upstream turbine **203** and the downstream turbine **204**.

However, when the collector is the slit attached stator vane **312**, a difference in the suction pressure, that is, a difference in the pressure between the inflow place of the collected matter **201** and the periphery of a slit **307** as the outflow place (the collection place Y) of the collected matter **201** is set to a degree that moisture may be sufficiently suctioned outward.

Further, in the embodiment, not the collected matter **201**, but the gas separated from the collected matter **201** is made to flow between the upstream turbine **203** and the downstream turbine **204** through the collected matter path P. This will be specifically described later.

Here, a gas-liquid separator **212** shown in FIG. **1** will be described.

In the embodiment, the gas-liquid separator **212** is disposed on the collected matter path P, and the collected matter **201** is made to flow into the gas-liquid separator **212**. The gas-liquid separator **212** separates the collected matter **201** into a gas **211** and a liquid **213**. The gas **211** is steam, and the liquid **213** is water.

Subsequently, the gas **211** is made to flow into the steam by the collected matter path P, where the steam reaches from the outlet of the final-stage rotor vane **301** of the upstream turbine **203** to the inlet of the final-stage rotor vane of the downstream turbine **204**. On the other hand, the liquid **213** is made to flow into the condenser **104** by the separated liquid path Px. In the embodiment, a liquid passage valve **214** is provided on the separated liquid path Px.

In the embodiment, for example, the collected matter **201** collected from the slit attached stator vane **312** is inserted into a gas-liquid separation tank which is a type of the gas-liquid separator **211**, and the collected matter **201** is separated into the gas **211** and the liquid **213** by the gravity.

When the collector is the drain catcher **304** or the drain catcher **304** and the groove attached rotor vane **311**, the collected matter **201** is moisture. However, when the collected matter **201** is made to flow into the gas-liquid separation tank, a part of the collected matter **201** evaporates due to the pressure loss and the heat transfer up to the tank, so that the gas **211** and the liquid **213** are present inside the tank.

The separated gas **211** and the liquid **213** are respectively made to flow into the lower pressure place. The water as the liquid **213** is extracted from the bottom surface of the tank, and flows as the liquid **213** into the condenser **104**. On the other hand, the steam as the gas **211** is extracted from the upside of the tank, and flows as the gas **211** into a position between the outlet of the final-stage rotor vane **301** of the upstream turbine **203** and the inlet of the final-stage rotor vane of the downstream turbine **204**. Furthermore, the separation of the gas **211** and the liquid **213** may be realized by a method such as a gas-liquid separation membrane other than the gas-liquid separation tank.

In the embodiment, the gas-liquid separator **212** separates the collected matter **201** or the resultant matter changed from the collected matter **201** into the gas **211** and the liquid **213**, and the collected matter path P makes the separated gas **211** flow between the upstream turbine **203** and the downstream turbine **204**. That is, in the embodiment, moisture is collected from the steam which exists upstream of the inlet of the final-stage rotor vane **301** inside the upstream turbine **203**, and the steam subjected to the removal of the moisture is made to flow into the steam between the outlet of the final-stage rotor vane **301** of the upstream turbine **203** and the inlet of the final-stage rotor vane of the downstream turbine **204**. Accordingly, it is possible to obtain an excellent effect that the loss of the moisture in at least the final-stage rotor vane **301** of the upstream turbine **203** may be reduced.

When the upstream turbine **203** is provided with the collector and the collected matter path P and the gas-liquid separator **212** is disposed on the collected matter path P, there is an advantage in that the flow rate of the steam of the downstream turbine **204** less decreases. When the collector is the slit attached stator vane **312**, the enthalpy of the accompanying steam is utilized without being directly discarded to the condenser **104**, and is used as a part of the output of the power generation in the downstream turbine **204**. Therefore, according to the embodiment, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the turbine cycle.

On the other hand, the liquid **213** separated from the collected matter **201** is returned to the condenser **104** without being discarded, and is effectively used in the subsequent cycle. Furthermore, the separated liquid **213** is not made to directly flow into the condenser **104**. For example, the separated liquid is first mixed with the drain water generated in the feed-water heater **121**, is used by each feed-water heater **121** to heat feed-water **111**, and then is merged with the feed-water **111** by a drain water pump **122**. Accordingly, the heat of the separated liquid **213** may be effectively used, and the efficiency of the steam turbine cycle may improve. In this case, a configuration may be adopted in which the separated liquid **213** is not merged with the feed-water **111** by the drain water pump **122**, but used by each feed-water heater **121** to heat the feed-water **111** and made to finally flow into the condenser **104**.

Furthermore, in the embodiment, the collector is disposed at a position where moisture is collected from the steam which exists upstream of the inlet of the final-stage rotor vane **301** inside the upstream turbine **203**. There are advantages in that the amount of the moisture contained in the steam behind the collection position inside the upstream turbine **203** decreases, the moisture loss at the stage of the upstream turbine behind the collection position is reduced, and the internal efficiency of the turbine improves. Further, there is an advantage in that erosion at upstream and downstream turbine vanes behind the collection position is reduced.

Further, in the embodiment, not the collected matter **201**, but the gas **211** separated from the collected matter **201** is made to flow into the steam between the outlet of the final-stage rotor vane **301** of the upstream turbine **203** and the inlet of the final-stage rotor vane of the downstream turbine **204**. Accordingly, not steam and moisture, but only steam may be made to flow into the downstream turbine **204**. Then, when moisture is removed from the steam inside the upstream turbine **203**, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture.

Hereinafter, second to seventeenth embodiments will be described. Since those embodiments are modifications of the first embodiment, those embodiments will be described by focusing on differences from the first embodiment.

(Second Embodiment)

FIG. **2** is a schematic diagram illustrating a configuration of the steam turbine plant of the second embodiment.

In the embodiment, the gas-liquid separator **212** separates the collected matter **201** or the resultant matter changed from the collected matter **201** into the gas **211** and the liquid **213**, and the collected matter path P makes the separated gas **211** flow into the inlet or the halfway stage of the downstream turbine **204**. In the latter case, the gas **211** flows between the inlet of the downstream turbine **204** and the inlet of the final-stage rotor vane.

Here, the first embodiment and the second embodiment will be compared with each other.

In the first embodiment, since the collected matter **201** is made to flow into the upstream inflow place compared to the second embodiment, there is an advantage in that the performance of the steam turbine cycle may become more efficient.

On the other hand, in the second embodiment, since the collected matter **201** is made to flow into the downstream inflow place compared to the first embodiment, it is easy to ensure a difference in the pressure between the inflow place and the outflow place of the collected matter **201**. As a result, there is an advantage in that the collected matter **201** easily flows into the inflow place.

According to the embodiment, when removing moisture from the steam inside the upstream turbine **203**, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture, as in the first embodiment. However, in the embodiment, there is an advantage in that a difference in the suction pressure is easily ensured compared to the first embodiment.

(Third Embodiment)

FIG. **3** is a schematic diagram illustrating a configuration of the steam turbine plant of the third embodiment.

The collector of the embodiment is a moisture separator **231** which separates moisture from upstream turbine exhaust **123** and collects the separated moisture as the collected matter **201**. In the embodiment, the upstream turbine exhaust **123** is humid steam, and flows into the moisture separator

231. The moisture, the collected matter **201**, separated from the upstream turbine exhaust **123** by the moisture separator **231** is exhausted to the collected matter path P. The moisture separator **231** used in the embodiment may be of any type.

In the embodiment, when the humidity of the upstream turbine exhaust **123** is very high, it is possible to remove most of moisture (the collected matter **201**) from the exhaust **123** using the moisture separator **231** without making the total amount of the upstream turbine exhaust **123** flow into the downstream turbine **204**. In this case, the remaining steam **232** subjected to the removal of the moisture is made to flow into the downstream turbine **204**. In FIG. **3**, a separated steam path P_Y making the steam **232** subjected to the removal of the moisture flow into the downstream turbine **204** is denoted by P_Y.

In the embodiment, the collected matter **201** from the moisture separator **231** is moisture or moisture and steam. The collected matter path P of the embodiment makes the collected matter **201** flow into the feed-water **111** between the condenser **104** and the boiler **108**. However, since there is a need that the inflow place has a pressure lower than that around the moisture separator **231** in order to make the collected matter **201** easily flow into the inflow place, the collected matter path P of the embodiment makes the collected matter **201** flow into a position between the condenser **104** and the plurality of pumps **105**.

If the collected matter **201** is discarded to the condenser **104**, since the collected matter **201** is cooled by the cooing water, latent heat and sensible heat of the accompanying steam contained in the collected matter **201** or sensible heat of the water contained in the collected matter **201** are wasted. However, in the embodiment, since the collected matter **201** is made to flow into the feed-water **111**, the heat input amount of the boiler **108** decreases as much as latent heat and sensible heat of the collected matter **201** are not wasted, and deterioration in the performance of the steam turbine cycle is reduced.

As described above, according to the embodiment, when moisture is removed from the exhaust of the upstream turbine **203**, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture. Specifically, according to the embodiment, the performance of the steam turbine cycle may improve as much as latent heat and sensible heat of the collected matter **201** are not wasted.

(Fourth Embodiment)

FIG. **4** is a schematic diagram illustrating a configuration of the steam turbine plant of the fourth embodiment.

The collector of the embodiment is the moisture separator **231** which separates moisture from the upstream turbine exhaust **123** and collects at least the separated moisture as the collected matter **201** as in the third embodiment. In the embodiment, the upstream turbine exhaust **123** is humid steam, and flows into the moisture separator **231**.

The collected matter path P of the embodiment makes the collected matter **201** flow into a feed-water heater **223** heating the feed-water **111** from the condenser **104** or a position between the extraction port E of the upstream turbine **203** or the downstream turbine **204** and the feed-water heater **223**. However, the extraction port E is set to a place which is located at the downstream of the collection place Y and has a lower pressure. In FIG. **4**, the collected matter **201** is made to flow between the extraction port E of the downstream turbine **204** and the feed-water heater **223**. In FIG. **4**, the feed-water heater into which the collected matter **201** flows and the other feed-water heater are classified by the reference numeral **223** and the reference numeral **121**.

In FIG. **4**, the extraction steam from the extraction port E of the downstream turbine **204** is denoted by the reference numeral **221**. The collected matter path P of the embodiment makes the collected matter **201** merge with the extraction passage through which the extraction steam **221** flows. In FIG. **4**, the extraction steam merging with the collected matter **201** is denoted by the reference numeral **222**. The extraction steam **222** flows into the feed-water heater **223**, is used as the heat source of the feed-water **111**, and merges with the feed-water **111** after heating the feed-water **111**.

If the collected matter **201** is discarded to the condenser **104**, since the collected matter **201** is cooled by the cooling water, sensible heat of the collected matter **201** is wasted. However, in the embodiment, since the collected matter **201** merges with the extraction steam **221**, the heat input amount of the boiler **108** decreases as much as the sensible heat of the collected matter **201** is not wasted, and deterioration in the performance of the steam turbine cycle is reduced.

Further, in the embodiment, since the steam turbine cycle is similar to the Carnot cycle compared to the third embodiment in which the collected matter **201** is directly merged with the feed-water **111**, the performance of the steam turbine cycle improves.

As described above, according to the embodiment, when moisture is removed from the exhaust of the high pressure turbine **101**, the performance of the steam turbine cycle may improve as much as the sensible heat of the collected matter **201** is not wasted.

Furthermore, the feed-water heater **223** of the embodiment also includes a deaerator which deaerates the feed-water **111** with the inflow of the extraction steam **222**.

(Fifth Embodiment)

FIG. **5** is a schematic diagram illustrating a configuration of the steam turbine plant of the fifth embodiment.

The collector of the embodiment is the moisture separator **231** which separates moisture from the upstream turbine exhaust **123** and collects at least the separated moisture as the collected matter **201** as in the third and fourth embodiments. In the embodiment, the upstream turbine exhaust **123** is humid steam, and flows into the moisture separator **231**.

In FIG. **5**, the feed-water pump **224** is disposed on the passage between the condenser **104** and the boiler **108** to transfer the feed-water **111**. Furthermore, in FIG. **5**, the feed-water pump driving steam turbine **225** is disposed on the passage between the extraction port E of the upstream turbine **203** or the downstream turbine **204** and the condenser **104** to drive the feed-water pump **224**. However, the extraction port E is set to a place which has the same pressure as the collection place X, or a place which is located at the downstream of the collection place Y and has a lower pressure. The collected matter path P of the embodiment makes the collected matter **201** flow into the feed-water pump driving steam turbine **225** or the extraction passage to the feed-water pump driving steam turbine **225**.

In FIG. **5**, the extraction steam from the extraction port E of the upstream turbine **203** is denoted by the reference numeral **221**. The collected matter path P of the embodiment makes the collected matter **201** merge with an extraction passage through which the extraction steam **221** flows. In FIG. **5**, the extraction steam merging with the collected matter **201** is denoted by the reference numeral **222**. The extraction steam **222** flows into the feed-water pump driving steam turbine **225** and circulates while decreasing in both the pressure and the temperature, so that it drives the feed-water pump driving steam turbine **225**.

The feed-water pump driving steam turbine exhaust **226** sufficiently decreases in both the pressure and the temperature, and flows into the condenser **104**. The feed-water pump **224** is driven by power obtained from the feed-water pump driving steam turbine **225**.

Since the amount of the collected matter **201** merging with the extraction steam **221** is extremely small compared to the peripheral steam, the collected matter changes into steam by being heated by the peripheral steam, and is used as a part of the steam for driving the feed-water pump driving steam turbine **225**.

If the collected matter **201** is discarded to the condenser **104**, since the collected matter **201** is cooled by the cooling water, sensible heat and pressure of the collected matter **201** are wasted. However, in the embodiment, since the collected matter **201** merges with the extraction steam **221**, the heat input amount of the boiler **108** decreases as much as the sensible heat and the pressure of the collected matter **201** are not wasted, and deterioration in the performance of the steam turbine cycle is reduced.

Further, in the embodiment, since the collected matter **201** is used in the feed-water pump driving steam turbine **225**, it is possible to decrease the amount of the extraction steam. Therefore, according to the embodiment, the flow rate of the turbine steam at the downstream of the extraction place of the extraction steam **221** less decreases, and the output of the power generation and the performance of the steam turbine cycle improve.

As described above, according to the embodiment, when moisture is removed from the exhaust of the upstream turbine **203**, the performance of the steam turbine cycle may improve as much as the sensible heat and the pressure of the collected matter **201** are not wasted.

(Sixth Embodiment)

FIG. **6** is a schematic diagram illustrating a configuration of the steam turbine plant of the sixth embodiment.

In the embodiment, the gas-liquid separator **212** separates the collected matter **201** or the resultant matter changed from the collected matter **201** into the gas **211** and the liquid **213**, and the collected matter path P makes the separated gas **211** flow into the steam between the collection place of the collected matter **201** inside the upstream turbine **203** and the inlet of the final-stage rotor vane. In FIG. **6**, the collection place (the outflow place) of the collected matter **201** is denoted by the reference character Y, and the inflow place of the collected matter **201** is denoted by the reference character Z.

In FIG. **6**, there is a need to pay attention that the inflow place Z of the collected matter **201** is located at the downstream of the collection place Y. In the embodiment, the inflow place Z of the collected matter **201** is installed at the downstream place of the closest rotor vane **301** located at the downstream of the collection place Y.

When the collector is the slit attached stator vane **312**, the inflow place Z is installed at the downstream of the rotor vane **301** located right behind the slit attached stator vane **312**. In this case, the inflow place Z is installed at a place where a difference in the suction pressure, that is, a difference in the pressure between the vicinity of the slit **307** and the inflow place Z is set to an appropriate value. When a difference in the pressure is large, the pressure difference is adjusted on the basis of the opening degree of the valve **202**. When the collector is the slit attached stator vane **312**, the enthalpy of the accompanying steam is utilized without being directly discarded to the condenser **104**, and is used as a part of the output of the power generation.

When the collector is the drain catcher **304** or the groove attached rotor vane **311** and the drain catcher **304**, the inflow place Z is installed at the downstream of the rotor vane **301** right behind the drain catcher **304**. Accordingly, there is an advantage in that the flow rate of the steam right behind the inflow place Z less decreases.

As described above, according to the embodiment, when moisture is removed from the steam inside the steam turbine, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture. Furthermore, in the embodiment, when humid steam is present inside the downstream turbine **204**, the collection place Y and the inflow place Z of the collected matter **201** may be provided in the downstream turbine **204**.

(Seventh Embodiment)

FIG. **7** is a schematic diagram illustrating a configuration of the steam turbine plant of the seventh embodiment.

In the first embodiment (FIG. **1**), the liquid **213** is made to flow into the condenser **104** by the separated liquid path Px. On the contrary, in the seventh embodiment (FIG. **7**), the liquid **213** is made to flow into a position between the condenser **104** and the plurality of pumps **105** by the separated liquid path Px.

As in FIG. **1**, when the liquid **213** is discarded to the condenser **104**, sensible heat contained in the liquid **213** is wasted. However, in FIG. **7**, since the liquid **213** is made to flow into the feed-water **111**, the heat input amount of the boiler **108** decreases as much as sensible heat of the liquid **213** is not wasted, and deterioration in the performance of the steam turbine cycle is reduced.

As described above, according to the embodiment, when moisture is removed from the steam which exists upstream of the inlet of the final-stage rotor vane in the upstream turbine **203**, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture. Specifically, according to the embodiment, the performance of the steam turbine cycle may improve as much as sensible heat of the liquid **213** is not wasted.

(Eighth Embodiment)

FIG. **8** is a schematic diagram illustrating a configuration of the steam turbine plant of the eighth embodiment.

In the first embodiment (FIG. **1**), the liquid **213** is made to flow into the condenser **104** by the separated liquid path Px. On the contrary, in the eighth embodiment (FIG. **8**), the liquid **213** is made to flow into the extraction steam **221** between the extraction port E of the upstream turbine **203** or the downstream turbine **204** and the feed-water heater **223** or into the feed-water heater **223** by the separated liquid path Px.

As in FIG. **7**, when the liquid **213** is discarded to the condenser **104**, sensible heat contained in the liquid **213** is wasted. However, in FIG. **8**, since the liquid **213** is made to flow into the extraction steam **221**, the heat input amount of the boiler **108** decreases as much as sensible heat of the liquid **213** is not wasted, and deterioration in the performance of the steam turbine cycle is reduced.

Further, in the embodiment, since the steam turbine cycle is similar to the Carnot cycle compared to the seventh embodiment in which the liquid **213** is directly merged with the feed-water **111**, the performance of the steam turbine cycle improves.

As described above, according to the embodiment, when moisture is removed from the exhaust of the upstream turbine **203**, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture, as in the seventh embodiment.

(Ninth Embodiment)

FIG. **9** is a schematic diagram illustrating a configuration of the steam turbine plant of the ninth embodiment.

In the first embodiment (FIG. **1**), the liquid **213** is made to flow into the condenser **104** by the separated liquid path Px.

On the contrary, in the ninth embodiment (FIG. **9**), the liquid **213** is made to flow into the feed-water pump driving steam turbine **225** or the extraction passage to the feed-water pump driving steam turbine **225** by the separated liquid path Px. However, the extraction port E to the turbine **225** is set to a place which is located at the downstream of the collection place Y and has a lower pressure.

Since the amount of the collected matter **201** merging with the extraction steam **221** is extremely small compared to the peripheral steam, the collected water changes into steam by being heated by the peripheral steam, and is used as a part of the steam for driving the feed-water pump driving steam turbine **225**.

As in FIG. **1**, when the liquid **213** is discarded to the condenser **104**, sensible heat and pressure of the liquid **213** are wasted. However, in FIG. **9**, since the liquid **213** is merged with the extraction steam **221**, the heat input amount of the boiler **108** decreases as much as the sensible heat and the pressure of the liquid **213** are not wasted, and deterioration in the performance of the steam turbine cycle is reduced.

Further, in the embodiment, since the liquid **213** is used in the feed-water pump driving steam turbine **225**, it is possible to decrease the amount of the extraction steam. Therefore, according to the embodiment, the flow rate of the turbine steam at the downstream of the extraction place of the extraction steam **221** less decreases, and the output of the power generation and the performance of the steam turbine cycle improve.

As described above, according to the embodiment, when moisture is removed from the exhaust of the upstream turbine **203**, it is possible to reduce deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture, as in the seventh and eighth embodiments.

(Tenth Embodiment)

The tenth embodiment is shown in FIGS. **3** to **5**. Hereinafter, the tenth embodiment will be described by referring to FIG. **3**.

In the embodiment, the collected matter path P is provided with the valve **202** which is an opening/closing valve for stopping the circulation of the collected matter **201** or a pressure adjustment valve for adjusting the flow rate of the collected matter **201**.

In the solar power generation, a heat medium **118** stored in a heat storage tank is circulated while bypassing a solar energy collector **119** at nighttime when solar rays **117** (FIG. **12**) cannot be received or daytime when the solar rays **117** are weak. Accordingly, the running state of each turbine changes. Further, since the state of the solar rays **117** is different due to the climate, the season, and the time even at daytime the running state of each turbine changes in response thereto.

For this reason, the steam of the outflow place of the collected matter **201** may not be humid steam in accordance with the running state of the turbine. In this case, since the collected matter **201** is not collected, dry steam circulates in the collected matter path P. In this case, the output of the turbine or the performance of the turbine cycle deteriorates. Further, even when the steam of the outflow place of the collected matter **201** is humid steam with low humidity, the collection amount of the moisture becomes smaller and the collection amount of the steam becomes larger, so that the output of the turbine or the performance of the turbine cycle deteriorates.

In this case, in the embodiment, when the valve **202** is fully closed, the output of the turbine or the performance of the turbine cycle may be maintained without any deterioration.

Further, in the embodiment, when the collector is the slit attached stator vane **312**, a difference in the suction pressure may be adjusted on the basis of the opening degree of the valve **202**. Accordingly, for example, the suction amount of the accompanying steam may be decreased.

In the embodiment, it is possible to adjust a difference in the pressure in accordance with the running state of the turbine. Even when the collector is the drain catcher **304** or the groove attached rotor vane **311** and the drain catcher **304**, if the humidity of the steam of the outflow place of the collected matter **201** is small, the steam other than the moisture easily flows outward. Therefore, in this case, when the opening degree of the valve **202** is adjusted and the outflow of the collected matter **201** from the drain catcher **304** is slowed down, it is possible to suppress the outflow of the steam other than the moisture.

As described above, according to the embodiment, it is possible to desirably control the circulation or the flow rate of the collected matter **201** circulating in the collected matter path P by using the valve **202** which is the opening/closing valve and the pressure adjustment valve.

(Eleventh Embodiment)

The eleventh embodiment is shown in FIGS. **1** and **2** and FIGS. **6** to **9**. Hereinafter, the eleventh embodiment will be described by referring to FIG. **1**.

In the embodiment, the collected matter path P at the downstream of the gas-liquid separator **212** is provided with the valve **202** which is an opening/closing valve for stopping the circulation of the gas **211** or a pressure adjustment valve for adjusting the flow rate of the gas **211**. Further, the separated liquid path Px is provided with a liquid passage valve **214** which is an opening/closing valve for stopping the circulation of the liquid **213** or a pressure adjustment valve for adjusting the flow rate of the liquid **213**.

In the embodiment, in accordance with the running state of the turbine, the valve **202** is adjusted to be fully closed or the opening degree thereof is adjusted, and the liquid passage valve **214** is adjusted to be fully closed or the opening degree thereof is adjusted. Accordingly, it is possible to obtain the same effect as that of the tenth embodiment. In the embodiment, the opening/closing valve or the pressure adjustment valve may be installed on the collected matter path P from the collection place Y of the collected matter **201** to the gas-liquid separator **212**.

As described above, according to the embodiment, it is possible to desirably adjust the circulation or the flow rate of the gas **211** and the liquid **213** separated from the collected matter **201** by using the valve **202** and the liquid passage valve **214** which are the opening/closing valve or the pressure adjustment valve.

(Twelfth Embodiment)

The twelfth embodiment is shown in FIG. **14**. The collector of FIG. **14** may be used in combination with the first, second, or sixth to ninth embodiments.

In the embodiment, a drain catcher **304** is installed at the inner wall surface **303** on the outer peripheral side of the casing of the upstream turbine **203** to collect moisture. Accordingly, it is possible to collect the moisture present in the inner wall surface **303**. In the embodiment, there is an advantage in that the collector may be realized with a simple structure.

(Thirteenth Embodiment)

The thirteenth embodiment is shown in FIG. **15**. The collector of FIG. **15** may be used in combination with the first, second, or sixth to ninth embodiments.

In the embodiment, a groove **305** is provided on the surface of the rotor vane **301** of the upstream turbine **203** in a direction from the inner periphery toward the outer periphery thereof. Further, the drain catcher **304** is provided at the inner wall surface **303** on the outer peripheral side of the casing of the upstream turbine **203**. Accordingly, it is possible to make the moisture collected by the groove **305** fly toward the inner wall surface **303** due to the centrifugal force and collect it by the drain catcher **304**. In the embodiment, there is an advantage in that moisture may be more actively removed compared to the twelfth embodiment.

(Fourteenth Embodiment)

The fourteenth embodiment is shown in FIGS. **16** to **18**. The collector of FIGS. **16** to **18** may be used in combination with the first, second, or sixth to ninth embodiments.

In the embodiment, the slit **307** is provided on the surface of the stator vane **302** of the upstream turbine **203**. Further, a passage of a hollow space **308** is provided inside the stator vane **302** to extend from the slit **307** toward the outer periphery thereof. Accordingly, a structure is realized in which the moisture present on the surface of the stator vane **302** is collected and is made to flow to the outside of the upstream turbine **203**.

The moisture or the humid steam present on the surface of the stator vane **302** is suctioned outward by using a difference in the pressure between the outflow place and the inflow place of the collected matter **201**. In the embodiment, there is an advantage in that moisture may be more actively removed compared to the twelfth and thirteenth embodiments.

Further, in the thirteenth embodiment, since the shape of the groove attached rotor vane **311** is not best suitable for the aerodynamic viewpoint, the performance of the steam turbine cycle deteriorates, whereas according to the slit attached stator vane **312** of the embodiment, such deterioration in the performance may be prevented.

Furthermore, in FIGS. **14** to **18**, the condenser **104** is shown as the outflow place of the collected matter **201**, but it shows a case where the collector of FIGS. **14** to **18** is applied to several steam turbine plants of FIGS. **10** to **13**. When the collector of FIGS. **14** to **18** is applied to any one of the first to ninth embodiments, the outflow place of the collected matter **201** is the place shown in the description of the embodiments.

(Fifteenth Embodiment)

The fifteenth embodiment may be used in combination with any one of the first to ninth embodiments.

In the fifteenth embodiment, the steam turbine constituting the steam turbine plant is driven by steam generated by solar heat. In the steam turbine plant using solar heat, compared to the steam turbine plant using heat of combustion exhaust of a fuel, the temperature of the turbine inlet steam is low, and the steam at the halfway stage of the turbine easily becomes humid steam.

Therefore, the effect of reducing deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture in the first to ninth embodiments may be more effectively exhibited when these embodiments are applied to the solar power generation.

(Sixteenth Embodiment)

The sixteenth embodiment may be used in combination with any one of the first to ninth embodiments.

In the sixteenth embodiment, the steam turbine constituting the steam turbine plant is used as a steam turbine for geothermal power generation. In the steam turbine plant for the geothermal power generation, it is common that the humidity of the turbine inlet steam is not zero, and the humidity increases as the steam progresses to the downstream.

Therefore, the effect of reducing deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture in the first to ninth embodiments may be more effectively exhibited when these embodiments are applied to the geothermal power generation where a large amount of moisture is contained in the steam.

FIGS. **19**A and **19**B are schematic diagrams illustrating configurations of steam turbine plants for solar power generation and geothermal power generation, respectively. Hereinafter, differences between the configurations of those plants will be described by referring to FIGS. **19**A and **19**B.

FIGS. **19**A and **19**B respectively schematically illustrate the configurations of the steam turbine plants for the solar power generation and the geothermal power generation. In FIG. **19**A, the water **111** from the condenser **104** is returned to the boiler **108** to be reused, whereas in FIG. **19**B, the water **111** from the condenser **104** is not returned to the boiler **108**. That is, the steam turbine cycle for the geothermal power generation is an open cycle.

The steam turbine plant of FIG. **19**B includes a separator **321**, a hot water pump **325**, and a cooling tower **326**.

The separator **321** is configured to separate natural steam **322** from a production well into dry steam **323** and hot water **324**. The steam **323** is used to drive a turbine group **331** including the upstream turbine **203** and the downstream turbine **204**, and the hot water **323** is returned to a reduction well.

The hot water pump **325** is a pump which transfers the hot water **327** from the condenser **104** to the cooling tower **326**. The cooling tower **326** is a structure which cools the hot water **327** through the contact with the atmosphere. The hot water **327** is cooled into the cold water **328** by the cooling tower **326**. The cold water **328** is transferred to the condenser **104**, and is used to change steam into water. Furthermore, the extra cold water **328** is returned as overflow water **329** to the reduction well.

Furthermore, regarding the configuration between the turbine group **331** and the condenser **104** shown in FIGS. **19**A and **19**B, any one of configurations shown in FIGS. **1** to **13** may be adopted.

(Seventeenth Embodiment)

The seventeenth embodiment may be adopted in combination with any one of the first to ninth embodiments.

In the seventeenth embodiment, the steam turbine constituting the steam turbine plant is a steam turbine used for nuclear power generation. In the steam turbine plant of the nuclear power generation, the humidity of the turbine inlet steam is not zero in many cases, and the humidity thereof becomes higher as the steam moves to the downstream.

Therefore, the effect of reducing deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of the moisture in the first to ninth embodiments may be more effectively exhibited when these embodiments are applied to the nuclear power generation in which a considerably large amount of moisture is contained in the steam.

As described above, according to the embodiments of the invention, it is possible to provide the steam turbine plant capable of reducing deterioration in the output of the power generation and deterioration in the performance of the steam turbine cycle with the removal of moisture when the moisture is removed from the steam inside the upstream turbine **203** or the exhaust of the upstream turbine **203**.

While examples of specific aspects of the invention have been explained with reference to the first to seventeenth embodiments, the invention is not limited to those embodiments.

The invention claimed is:

1. A steam turbine plant comprising:

a boiler configured to change water into steam;

an upstream turbine including plural stages of rotor vanes and plural stages of stator vanes, and configured to be driven by the steam from the boiler;

a downstream turbine including plural stages of rotor vanes and plural stages of stator vanes, connected to the upstream turbine via no reheater, and configured to be driven by the steam exhausted from the upstream turbine;

a condenser configured to change the steam exhausted from the downstream turbine into water;

a collector configured to collect water from the steam which exists upstream of an inlet of the final-stage rotor vane in the upstream turbine, or the steam exhausted from the upstream turbine to drive the downstream turbine; and

a collected matter path configured to cause collected matter in the collector to flow into:

the steam between an outlet of the final-stage rotor vane of the upstream turbine and an inlet of the final-stage rotor vane of the downstream turbine,

the steam between a collection place of the collected matter and the inlet of the final-stage rotor vane in the upstream turbine,

the steam extracted from an extraction port of the upstream turbine or the downstream turbine, wherein the collected matter having passed no feed-water heater flows into the extracted steam from the extraction port,

a feed-water heater configured to receive the extracted steam from the extraction port through no feed-water heater and heat the water exhausted from the condenser and flowing between the condenser and the boiler by using the extracted steam merged with the collected matter which has passed no feed-water heater, wherein the collector collects the water from the steam which exists upstream of the inlet of the final-stage rotor vane in the upstream turbine, or

a feed-water-pump-driving steam turbine configured to receive the extracted steam from the extraction port and be driven by the extracted steam merged with the collected matter which has passed no feed-water heater.

2. The plant of claim **1**, wherein the collected matter path is configured to cause the collected matter to flow into:

a position between the upstream turbine and the downstream turbine, or

an inlet or a halfway stage of the downstream turbine.

3. The plant of claim **1**, wherein the collected matter path is configured to cause the collected matter to flow into:

the feed-water heater configured to receive the extracted steam, and to heat the water from the condenser,

the feed-water-pump-driving steam turbine disposed between the extraction port and the condenser, and configured to receive the extracted steam, or

the extracted steam between the extraction port and the feed-water heater or the feed-water-pump-driving steam turbine.

4. The plant of claim **1**, further comprising a gas-liquid separator disposed on the collected matter path, and configured to separate the collected matter or resultant matter changed from the collected matter into a gas and a liquid,

wherein the collected matter path is configured to cause the separated gas to flow into:

the steam between the outlet of the final-stage rotor vane of the upstream turbine and the inlet of the final-stage rotor vane of the downstream turbine, or

the steam between the collection place of the collected matter and the inlet of the final-stage rotor vane in the upstream turbine.

5. The plant of claim **4**, wherein the collected matter path is configured to cause the separated gas to flow into:

a position between the upstream turbine and the downstream turbine,

an inlet or a halfway stage of the downstream turbine, or

a position between the collection place of the collected matter and the inlet of the final-stage rotor vane in the upstream turbine.

6. The plant of claim **4**, wherein the separated liquid is caused to flow into:

the feed-water heater configured to receive the extracted steam, and to heat the water from the condenser,

the feed-water-pump-driving steam turbine disposed between the extraction port and the condenser, and configured to receive the extracted steam, or

the extracted steam between the extraction port and the feed-water heater or the feed-water-pump-driving steam turbine.

7. The plant of claim **1**, wherein

the collector is a moisture separator configured to separate water from the steam exhausted from the upstream turbine, and to collect at least the separated water as the collected matter, and

the collected matter path is configured to cause the collected matter to flow into:

the extracted steam from the extraction port,

the feed-water heater configured to receive the extracted steam, or

the feed-water-pump-driving steam turbine configured to receive the extracted steam.

8. The plant of claim **7**, wherein the collected matter path is configured to cause the collected matter to flow into

the feed-water heater configured to receive the extracted steam, and to heat the water from the condenser,

the feed-water-pump-driving steam turbine disposed between the extraction port and the condenser, and configured to receive the extracted steam, or

the extracted steam between the extraction port and the feed-water heater or the feed-water-pump-driving steam turbine.

9. The plant of claim **1**, wherein

the collected matter path comprises a valve configured to stop a circulation of the collected matter, or to adjust a flow rate of the collected matter.

10. The plant of claim **4**, further comprising a separated liquid path configured to cause the separated liquid to circulate,

wherein

the collected matter path comprises a valve disposed downstream of the gas-liquid separator, and configured to stop a circulation of the separated gas or to adjust a flow rate of the separated gas, and

the separated liquid path comprises a valve configured to stop a circulation of the separated liquid, or to adjust a flow rate of the separated liquid.

11. A steam turbine plant comprising:

a boiler configured to change water into steam;

an upstream turbine including plural stages of rotor vanes and plural stages of stator vanes, and configured to be driven by the steam from the boiler;

a downstream turbine including plural stages of rotor vanes and plural stages of stator vanes, connected to the upstream turbine via no reheater, and configured to be driven by the steam exhausted from the upstream turbine;

a condenser configured to change the steam exhausted from the downstream turbine into water;

a collector configured to collect water from the steam which exists upstream of an inlet of the final-stage rotor vane in the upstream turbine, or the steam exhausted from the upstream turbine to drive the downstream turbine; and

a collected matter path configured to cause collected matter in the collector to flow into:

the steam between an outlet of the final-stage rotor vane of the upstream turbine and an inlet of the final-stage rotor vane of the downstream turbine,

the steam between a collection place of the collected matter and the inlet of the final-stage rotor vane in the upstream turbine,

the steam extracted from an extraction port of the upstream turbine or the downstream turbine to a steam path different from the collected matter path, wherein the collected matter having passed no feed-water heater flows into the extracted steam from the extraction port at a merging place of the collected matter path and the steam path,

a feed-water heater configured to receive the extracted steam which is exhausted from the extraction port to the steam path different from the collected matter path and has passed no feed-water heater and to heat the water exhausted from the condenser and flowing between the condenser and the boiler by using the extracted steam merged with the collected matter which has passed no feed-water heater, wherein the collector collects the water from the steam which exists upstream of the inlet of the final-stage rotor vane in the upstream turbine, or

a feed-water-pump-driving steam turbine configured to receive the extracted steam from the extraction port and be driven by the extracted steam merged with the collected matter which has passed no feed-water heater.

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